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Adapted Learning Environments for Future Education Systems

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Abstract

Today, teachers are expected to prepare their students to cope with the future, which, at this stage, is uncertain for both the students and the teachers. Scholars in the fields of education and occupational studies have identified a number of competencies that meet the needs of the 21st century and are required and essential for the success of a society, enterprise or any organizational unit. Therefore, educational institutions should provide their students at all levels with the ability to cope with situations which require these competencies. In this article we focus on action research regarding the work which has been conducted during the last four years mainly at the Teachers Training College and which aimed at suggesting new characteristics for learning environments at the educational institutions. Based on our previous work and experience in the field of learning and teaching, we will present a new perspective on the desired learning environment which includes the content, pedagogy and technology, as well as the interfaces among them. We will elaborate on the creation and usage of diverse and innovative learning spaces, aimed to reflect the contemporary reality in the 21st century places of employment and workplaces, and provide concrete examples of implementation of a pedagogical model in those spaces.

Keywords

Learning Environment, Learning Spaces, Innovative Pedagogy, Interdisciplinary Teaching, 21st Century Skills

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1. Introduction

Teachers who have completed their training express their capabilities and skills by demonstrating their ability to educate and prepare their students to cope with the future that at this stage is uncertain for both the students and the teachers. Nowadays, the world economy is dealing with constant and rapid changes in all the aspects of life. A graduate of education system, in addition to acquiring extensive and abundant knowledge, universal values and education to be a good citizen, in the future has to obtain skills that will allow him to cope with the changing environment and with significant uncertainty. At the same time, teachers training program, while continuing to engage in imparting areas of knowledge, should focus on the ability to create an atmosphere of openness, independence and the competency to cope with changes, which shall lead their students to meet the future challenges successfully.

Amar and Bar David [1] described in their article a number of skills that meet the needs of the 21st century economy and that, in their opinion, should be required of every graduate of the education system. In addition, many scholars in the fields of education and occupational studies [2, 3, 4, 5] described a number of competencies that, in the opinion of all of them, are required and essential for success of a society, enterprise or any organizational unit. These competencies include among the rest: pro-active social awareness, involvement, motivation, entrepreneurship, creativity and innovation,

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strategic thinking, collaboration, openness and flexible thinking, critical thinking, independence and accountability, social empathy etc. Educational institutions should provide their students at all levels with the ability to cope with situations, which shall require these competencies, prior to their joining the employment market and leading an active life.

2. Adjusting the TPCK Model

The components of the TPCK model are essential to modern teaching and learning [6]. Already in the 20th century, we saw how the components of the educational model began to change with the introduction of technology into educational institutions [7, 8].

Within the work of the article authors on the interfaces among the TPCK (Technology, Pedagogy and Content Knowledge) model components and the work that has been done during the recent years with the collaboration of the Steelcase company, the model was extended to include active observation in a learning environment adapted to the learning content, while integrating innovative teaching and pedagogic technologies. In this opinion article we wish to offer a new perspective on the TPCK model components and the interfaces among them. We shall try to examine the new perspective on the content, pedagogy, technology and learning environment, in the current age, when the duty of the education system is to do its best to prepare the students for the unknown larger world, which awaits them upon their graduation.

2.1. Content – The Importance of Interdisciplinary Teaching

The teaching content taught today is based upon unidimensional disciplinary teaching. In order to teach the content in a manner that allows the student to experience high-level thinking, the teachers should use advanced or innovative pedagogy, such as research-based learning or problem-based learning. Students taught according to existing teaching methods are unable to connect or attribute a particular area of knowledge to lateral topics originating in other areas of knowledge or disciplines and bring them to higher cognitive levels such as applying, analyzing, evaluating and creating, in addition to remembering and understanding [9]. This is also reflected in teachers' training programs. Pre-service teachers are required to study one or sometimes two teaching disciplines (sometimes they choose two areas of knowledge), but for the most part they are not trained to create the interdisciplinary links which require high-level thinking and synthesis between the different areas. The disciplines that are taught in isolation from one another do not allow for synchronization, going into depth and synthesis between the areas of knowledge as it is required of the natural cognitive processes occurring in our minds (as opposed to artificial cognitive processes that take place with the assistance of computerized systems). The many attempts to introduce innovative pedagogies have had limited success and have not yet become accepted teaching procedures in the education system as a whole [10]. Thus, we have to ask the following questions: How can we elevate the teaching and the learning not only to the level of absorbing and understanding but also to the high levels of cognitive perception and processing? And how can we promote influence of the studied material on the implementation and creativity?

In addition to the disciplines that will be taught by using both conventional and innovative pedagogies (such as languages, mathematics, grammar, etc.), we shall examine a group of profoundly and genuinely interconnected disciplines which should be taught using the interdisciplinary approach. Learning of these disciplines will be organized according to the respective ways of learning: i) Phenomenon-based learning; ii) Problem-based learning; iii) Research-based learning; and iv) Process and project-based learning. We will describe examples of interconnected disciplines and assign each way of learning a number of disciplines (areas of knowledge) which can be taught using the interdisciplinary approach, while implementing various pedagogies and technologies and sometimes even different and adapted learning environments.

a. Phenomenon-based learning: geography, history, economics, sociology and anthropology

b. Problem-based learning: mathematics, physics, robotics, geometry, computer science, computational thinking

c. Research-based learning:

i. Biology, chemistry, geography, biotechnology, biophysics

ii. Philosophy, sociology, history, art, religious studies, theology

d. Process and project-based learning: various intelligent combination of all the above-mentioned disciplines, based on a wish to outline logical processes or carry out applied projects.

We can mention a number of examples for each of the above-mentioned ways of teaching such as population or tribe migrations (Phenomenon-based learning), global warming, discovering color combinations for preschoolers (Research-based learning), disease propagation, bird migration, disappearance of civilizations (Process and project-based learning), continental drift (Combination of ways of learning), etc.

Of course, these are only suggested lists and their composition can be changed according to the age level. Areas of study can be added or removed to match their development or their disappearance from the landscape of human achievement and creativity. It is also possible to combine a number of different ways of learning and apply them to one subject or field, in the same classroom.

From the above description, we can infer that the same areas of interest will be taught using different ways of teaching. For instance, geography can be taught in depth using phenomenon-based learning. Yet it can also be taught through research-based learning, when teaching scientific topics such as global warming or population migration or ecological models/problems influenced by a tropical or a temperate climate. Such interdisciplinary learning will undoubtedly facilitate in-depth understanding of a particular field, its practical implementation, and especially the synthesis resulting from high-level thinking. All this serves to provide the students with skills and competencies that will enable them to use and implement the knowledge they have acquired. Students who understand how to use specific knowledge in a broad and holistic manner will have a better understanding of other relevant disciplines, which are related to this knowledge, and thus will be able to draw conclusions and arrive at profound and intelligent insights.

2.2. Pedagogy

Frontal teaching is still prevalent in most schools around the world. This method is based on the teaching methods practiced in most schools since the Industrial Revolution [11]. According to these methods, classrooms had a certain pre-defined size. There was a place for students who were seated in rows, and the teacher stood at the front of the classroom in a larger area, signaling the teacher's status in relation to that of the students and primarily representing the classroom hierarchy. Researchers worldwide [12, 13, 14] have described the transition from traditional frontal teaching and learning to active and collaborative learning whose goal is to facilitate a shift from generating personal and individual learning products to collective and collaborative ones achieved in a team effort. Amar and Bar David [1] described a new pedagogical model, which nowadays enjoys a new perspective based on coping with various challenges during the learning process. The model is now known by the name Challenge to Project Competency-based Education, and it allows incorporating all the above-mentioned ways of learning: phenomenon-based learning, problem-based learning, research-based learning, project and process-based learning. The major goal of the model is to allow for creating a matrix that enables learning, which will ultimately impart competencies composed of knowledge, skills and abilities suitable for the needs of the 21st century.

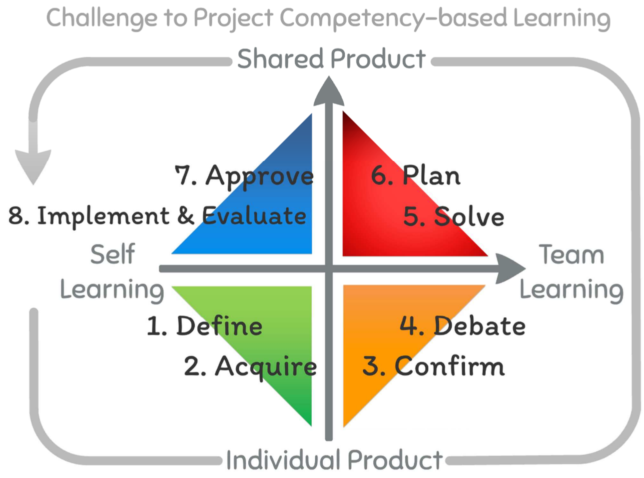

Figure 1. Challenge to Project Competency-Based Learning model.

This eight-stage model incorporates familiar and known learning and work processes which enable acquiring of additional skills of 21st century. The model moves along two main axes. On the horizontal axis, the learner moves from individual (self) work to teamwork, while on the vertical axis the learner is asked to move within the learning settings from individual products to shared products. The following are the eight stages of teaching/learning and the acquired/imparted skills during the learning process (chronological order is not necessarily required for continuing the individual or group learning).

Table 1. Eight stages of the "Challenge to Project Competency Based Learning" model.

Stage	Number of Students	Activity	Acquired Skill	Learning Product
Challenge Definition	Each student alone within the class framework	Defining the challenge and the ways of learning	Developing inquisitive and critical thinking, Coping with uncertainty	Individual Product
Knowledge Acquisition	Each student alone within the class framework	Searching for information on the Internet, in professional literature and consulting with the experts	Collecting and processing data, learning anytime and anywhere, learning through search and inquiry, understanding the technologies and using them as an advantage	Individual Product
Knowledge Confirmation	In pairs	Analyzing the information and turning it into knowledge, rhetorical dialogue	Developing inquisitive and critical thinking	Collective and Group Product
Debate	In groups of 4-6 students	Having a debate with presentation of the acquired knowledge and the personal insights	Collecting and processing data, Collaboration on all levels	Collective and Group Product

Stage	Number of Students	Activity	Acquired Skill	Learning Product
Solution	In groups of at least 6 students	Suggesting solutions to the challenge	Problem solving, innovation stemming out of existing solutions	Collective and Group Product
Planning	In groups of at least 6 students	Preparing a detailed plan for implementation of the solution	Team work, collaboration on all levels, innovative creativity, understanding the technologies and using them as an advantage	Collective and Group Product
Approval	Whole classroom	Presenting the challenge, the problem, the solution and the plan	Team work, collaboration on all levels	Individual Product
Implementation and Evaluation	Each student alone within the class framework	Going to the field for implementation of the suggested plan. Using evaluation methods for the whole process	Evaluation, reflection and constant control, innovative creativity	Individual Product

These eight stages occur at different periods of time, as determined by the lecturer/teacher and the progress rate of the individuals and the teams. The lecturer/teacher can decide to implement the entire model or only parts of it, in accordance with the sequence that seems most appropriate to the study content.

The model proposed above should bring about a complete change in the role of the teacher. The teacher remains a central and significant figure in the teaching and learning process. The teacher's presence in every stage of the process is most essential, however with a significant change. Instead of being a source of knowledge, the teacher becomes an educator, facilitator, moderator, advisor and trail guide. The teacher guides and assists in clarifying and understanding the challenge. Then he helps his students with searching and locating knowledge sources, filtering them and assembling the information. The teacher moderates group debates, listens to various suggested solutions, examines, evaluates and directs the students towards the learning processes that provide the desired skills. In the transition to implementation and evaluation, the teacher acts as a coach, an instructor and even as another learner among the students, as someone who learns from the process.

2.3. Technology

In the beginning of the 90's, Education ministries and departments began to define an organized program for introducing computers in schools [15]. Implementation of the ICT program involved planning intelligent learning environments, acquiring suitable equipment for implementing the program and recruiting guides and advisors for the schools. In the early 2000's in the wake of increased use of the Internet, the development of distance learning, school websites, learning and communication between the teachers and the students on the Internet have begun [16]. During the next few years, education systems begun the implementation of programs for adapting the education system to the 21st century [17]. In USA and OECD countries these programs stemmed from unsatisfactory results on the PISA exam and other similar international tests which indicated the gap between the schools from upper socio-economic status and the ones of lower socio-economic status and also between the developed countries. The objective of the programs was introducing innovative pedagogy in the schools and imparting 21st century skills while implementing information technologies.

The research studies that examined the success of programs and their implementation by teachers in the field showed that among the technological tools and services reported by the teachers, the use of visual demonstration tools and digital content applications stood out. The findings showed that most of the teachers used technology to supplement existing teaching-learning and were not implementing a profound change that would lead to a transition from traditional teaching to advanced digital teaching-learning [18].

Thus, even though these programs resulted in some improvement in learners' digital literacy, they did not meet the objectives for which they were developed: using innovative pedagogy in schools and imparting 21st century skills to graduates of the education system. Many teachers reported difficulties in working in a technological environment and difficulties in causing students to make proper use of technological tools. The main difficulty was the teachers' technophobia, stemming from the level of technological knowledge they brought to the classroom and the gap between the students' technological knowledge and skills compared to those of the teacher [10, 19].

Within our educational work, after introducing the technological aids such as: smart boards, projectors, laptops etc. and after the teachers have begun using computers in their work for teaching and learning management (sources of information, grading, presentations etc.), we have reached the conclusion that such use of available technologies does not actually alter the ways of teaching and pedagogy and does not encourage the imparting of advanced technological skills. Our suggestion was to change the perception of the use of technology and develop a different model composed of two components existing simultaneously in constant interaction:

a. Computational thinking, which is intended to provide the teachers and the learners with thinking skills, adapted to the technological world developing around them, both in their private lives and in the learning and teaching environment in which the learner is supposed to grow and the teacher develop. Those who learn in this way adopt high-level thinking methods that are parallel to the coding and programming processes in the computerized world and the teachers provide them with the platform for such thinking [20]. This enables learners and their teachers to adjust to a perspective in which they not only use computer technology but also take advantage of it for their learning or teaching objectives.

b. Internet of Things in Education (IOTE) is the intelligent integration of technology in Internet-based teaching and learning. This learning environment is positioned on the internet and offers objects ("things") that are backstage and supply information in real time. The learner can collect the data, process it and turn the information into knowledge using the tools at his disposal. Internet of Things can support the various studied areas of knowledge, but also allows for a continuous interaction between the learner and the teacher, and among the learners. It enables the learner to achieve constant and continuous improvement according to his personal level, which is evaluated by the system.

During the process of learning, going deeper and experiencing the computational thinking, the primary clients of the IOTE model, teachers and students, will operate in the environment where the two systems reinforce each other:

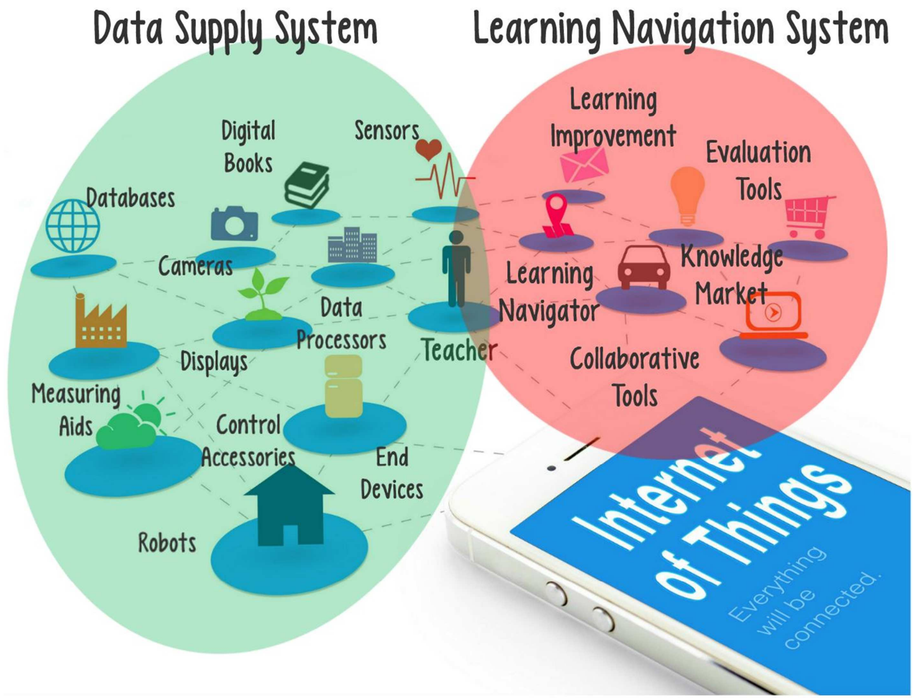

Figure 2. Internet of Things in Education (IOTE) model.

The Learning Navigation System: This system provides the teacher and the students with the learning objectives and the required learning targets (knowledge market), leads to collaboration and completion of information (collaborative tools) and allows the teacher and the student to evaluate the student's current accumulated level of knowledge (evaluation tools). The system will be able to refer the learner to learning materials via a path mapped for improvement of knowledge and its deeper understanding (tools for constant improvement) and finally to confirm and validate it with the relevant persons.

The Data Supply System: This system includes the "things" whose function is to serve as the source of information and to supply it in the desired configuration according to the areas of knowledge (sensors, cameras, digital books, measuring aids) to provide the data necessary for the student and the teacher in order to fulfill the assignments required to achieve the delineated targets (end devices, displays, robots, control accessories) and also the processing and analysis tools (databases, software, data processors). Thus, the system can offer areas of interest and learning and experiential activities for continuing learning, and finally shall enable receiving feedback and evaluation for achieving the constant improvement.

While these systems are technological by nature, technology is not at the center of the learning process. It is hidden, yet still supports and upgrades the learning. The technology provides the students with an in-depth understanding of the learning processes, details of the objectives they have to achieve and different ways to reach these objectives according to their preferences. For the teacher, these systems provide lesson plans, ways of learning and innovative pedagogies allowing him not to be the only source of knowledge and therefore have more time to deal with promoting skills to be imparted to the students and provide more focused assistance to the students both in personal and learning matters.

3. Learning Environments

The classrooms in most schools have not changed much over the past one hundred years. The teaching and learning in a traditional way cannot exist anymore, when we, as educators, are committed to impart to the students the advanced skills using innovative pedagogies and technologies. The above-mentioned teaching and learning characteristics, used according to adapted content, technology and pedagogy, cannot exist in traditional classrooms. The classroom should become learning spaces, which allow for pedagogy that incorporates adapted content and also advanced and innovative technologies for imparting 21st century skills [21]. In such learning spaces, the teachers and the students do not play the same roles than they used to in the past. In these spaces, the functional and territorial distinction, according to which the teacher provides the knowledge at the front of the class having larger space, while the student receives the knowledge having limited space, does not exist anymore. As the lesson progresses, they move around freely according to the student assignments. These learning environments include different models, that are suitable for diverse content, and various teaching methods, which allow for acquisition of the unique skills [22]. In light of the experience that has been accumulated during the recent years, we recommend that educational institutions adapt some of their classrooms by turning them into unique and dedicated learning environments adapted for the various learning content and for imparting the skills described by Amar and Bar David [1]. In the following section, we shall describe several examples of learning spaces currently operating in a number of institutions, including the one that employs the authors.

3.1. Dynamic Learning Space

A dynamic learning space serves the needs of collaborative pedagogical activities, as described above. The space consists of different learning rooms, each learning room includes equipment and aids for one or more stages of the dynamic pedagogic model (Challenge to Project Competency-based Learning). The various activity areas are equipped with various means, supplied by the Steelcase Company, that facilitate convenient and rapid transition from individual work to group work or teamwork. These areas also include technological aids for working with knowledge sources, and databases available to the students through laptops, tablets or portable personal devices. The means for individual and collaborative work facilitate breakthroughs and collaboration at any point of time while using different software for transition to collaborative work and presentation of personal and group learning products before all the students and the teachers involved in the process.

The learning space is located in adjacent rooms and via the joint corridor the students can pass from one room to another according to the model stages and their assignments. For the knowledge acquisition stage a unique space is required (in orange), however the use of technology is required through the whole process, with the aid of accessories at the disposal of the students during the whole process.

Figure 3. Dynamic learning space, designed in accordance to “Challenge to Project Competency-based Learning” model.

The learning space includes 4 rooms. Each room contains different parts of the pedagogical model:

a. Presenting and defining the problem is primarily a frontal stage (upper left corner), with the seats arranged in rows or in small or large circles. The seating arrangement allows for a quick transition from individual work to group work (in pairs or larger groups).

b. The knowledge acquisition stage requires technology and therefore takes place in a space equipped with advanced computerized technology and various options for collecting information and data and their processing, and presenting information and sharing it (upper right corner), individually, in pairs, as a team, group or before the whole classroom. Each learner appear can at any moment on the screens to request help or present his findings on the interactive electronic board located at the front of the learning space. The classroom is supported by the Steelcase's Media-Scape technology and the software for collaboration and for various presentation options.

c. The debate stage encourages development of rhetoric skills, respect of different opinions, integration of learning and mainly the possibility to express the understanding and the insights stemming from learning. This is the stage in which the group starts to adopt a certain position and defend it against the opposing group. This stage takes place in a learning space, which is equipped with Steelcase's Verb classroom furniture that we chose to arrange in an X configuration (lower right corner) in order to facilitate debates within and between the groups.

d. Suggestion of a solution stage allows for expression of computational thinking by creating a solution for the problem defined in the beginning of the lesson. In this case, also the group should unite around one agreed solution.

e. Project planning is the stage in which the group devises the plan for implementation of the suggested solution. The space includes individual and group erasable white boards that can be placed on the classroom walls while creating a gallery, which can be approached by the members of various groups in order to get an impression of the collaborative products that have been created during the previous processes.

f. Agreement is the stage before the last in the process in which an approval of the plans is obtained from the person who has been determined in the beginning as authorized to approve the implementation plan (teacher, internal or external educational entity etc.) (lower left corner).

g. Implementation and assessment is the last stage of the suggested plan. At this stage, the learners theoretically or practically experience the implementation of the approved plan and also draw the possible conclusions and realize the consequences of its implementation. Then the students carry out group reflection and discussion among all the learners. Finally, the individual self-assessment of the learning process, the acquired knowledge and the group work.

3.2. Continuous Learning Space

Besides the learning space that is composed of separate yet complementary sub-spaces, a larger and more meaningful space has been designed and developed, in which all the pedagogical activities take place in a single continuous space that allows for constant and continuous activity in accordance with the pedagogic needs of the lesson which is being conducted in the space.

In this space, called "the Future Space", various learning areas exist in the same space, which allows for all the stages of the pedagogical model to take place continuously and enables the collaborative work among the students and especially cooperation between several teachers who can present multidisciplinary learning process.

The various learning areas in this space are as follows:

a. Frontal area (1) – for problem definition, initial discussion and project presentation.

b. Technological area (2) – for immediate or ongoing knowledge acquisition.

c. Debate area (3) – for discussion and debate, solution presentation and project planning.

d. Instruction and guidance area (4) – for approval and confirmation with guidance, within small and heterogeneous groups.

e. Areas for imparting knowledge (5) – for teams to whom the lecturer wants to offer enrichment.

f. Quiet area (6) – for lecturers or learners to be by themselves for a certain period of time to hold short meetings or individual conferences with the students.

This kind of space is of course also appropriate for use of various pedagogies such as problem-based learning, project-based learning, phenomenon-based learning etc.

The following is an example of a teaching process in the continuous learning space, in which 90 students can participate.

Table 2. Implementation of "Challenge to Project Competency-based Learning" model in a continuous learning space.

Pedagogical Model Stage	Area of Main Events in the Learning Space	Description of the Activities
Challenge Definition	Frontal area (1)	a. The topic of the lesson is presented by the lecturer. He basically presents the challenge to the students and requests them to define the problem well. b. The students start formulating individually the problem based on the basic knowledge transferred to them by the lecturer, the problem that is compatible with the challenge that has been presented to them c. The lecturer, at this state, can divide the learners according to roles, or according to the areas of knowledge, which compose the topic/the area or the problem.
Knowledge Acquisition	Technological area (2)	a. The learners move to the technological area and start collecting independently and individually the information and the data that are relevant to the topic, the challenge and the problem that they have chosen. Collecting information is carried out by using bibliographic sources (articles, books and reports), internet sites, or experts located on the campus or elsewhere, who can be approached by e-mail or telephone. b. The learning initially takes place independently by using the internet sites, articles, books or experts outside the learning space. After a given period of time, the learners tell each other about their conclusions and insights and verify the acquired knowledge or confront those with different knowledge. c. The lecturer in this area assists the learners in finding the appropriate sources of knowledge.
Knowledge Approval	Technological area (2)	a. After gathering the information and the data, the students verify or confront what they learned with their peers, listen to each other and formulate (sometimes after corrections) the material required for continuation of the process. b. The lecturer goes from group to groups, helps them focus and makes sure that the desired knowledge is indeed learned. c. Then the synthesis of the learned material is made and its focus and relevance to the challenge/the problem, as it has been presented in the beginning, are examined
Debate	Debate area (3)	a. During the preliminary stages, the students naturally form groups whose members share the same interest or have arrived at the similar relevant knowledge. The groups that have been formed during the process start the discussions between them (sometimes heated but respectful). The discussions are intended for completing the missing parts of knowledge and arriving at the consensus regarding the content with which the group will continue to the next stages. b. The lecturer can at this stage, if he wishes to do so, establish new groups. New group will include one representative from each original group. The purpose of reorganization is to create a process of learners and teachers in which each member of the new team will play an active role in sharing the accumulated knowledge with the new group members. c. The lecturer moves from group to group, helps the participants conduct the debate properly and if necessary helps them focus, making sure that all members of the group present their opinions in an orderly fashion.
Creating a solution to the challenge	Debate area (3)	a. After the debate, the groups have reached agreements and the level of knowledge relevant for the presented challenge. Each groups starts creating the solution to the problem and converging on an agreed upon solution. b. The solution should refer to the studied content and must be relevant for the challenge/the studied problem. c. The lecturer examines the various suggestions and ensures that they are practical and can be implemented.
Planning an action plan	Instruction and guidance area (4)	a. The learners plan an action plan for implementation of the suggested solution. The action plan includes goals and objectives, milestones and timetables, persons in charge, budget or budgetary sources and also the indices of success.
Approval	Instruction and guidance area (4)	a. The learners present the action plan to the lecturer, who provides feedback, suggests corrections and finally approves the plan after making the required changes. b. After obtaining the approval from the lecturer, the learners present their plan of action to the other groups and after receiving feedback and remarks and presentation of all the plans of all the groups, a discussion takes place regarding the desired outcomes of the program implementation.
Presentation and assessment	Frontal area (1)	a. The groups start implementing the suggested solution, sometimes in roleplay within a group or between the groups and sometimes, in real life when there is a product or a plan that can be carried out in the field. b. One after another, the groups of learners present their suggested solution and its implications. The audience assesses the work according to pre-determined criteria or guidelines and expresses their opinions regarding the feasibility, creativity and quality of the project. c. The learners lead the assessment process (using the forms they have prepared in advance). The 360-degree assessment is performed, i.e. personal assessment, group assessment (project group), assessment of the other groups (colleagues) and assessment of the course lecturer. The assessment should consider not only the acquired knowledge and the process but also the skills, which have been acquired during the learning process.

Figure 4. Continuous Learning Space and its different learning areas.

Figure 5. Continuous Learning Space and its different learning areas.

3.3. Biophilic Space

In educational institutions, knowledge areas such as biology, zoology, botany, ecology, etc. are usually taught in frontal lessons integrated with traditional laboratories, where the students conduct experiments in test tubes, or on wax operating table. In these laboratories, the students study a process, a certain system or a reaction in specific artificial manner, when the learner expects results known in advance, as they are described in the textbook. On the other hand, natural processes that occur over a long time such as reproduction, photosynthesis, flowering etc. are taught in theoretical and concise manner, separate from parallel processes that occur in the nature. In reality, various processes influence one another and all the study topics exist simultaneously in synchronization and harmony. The environmental parameters influence both the reproduction and the flora, life of insects and flowering influence each other, climate conditions or recycling processes and alternative sources of energy are interdependent etc.

The average graduate of the education system, who chose to major in biology or environmental studies, is not required to enact higher-order thinking, which allows reaching the synthesis, which leads to insights stemming from the interaction between these processes.

Nowadays, we are witnessing more learning outside the classrooms. Such learning includes observation and its results allow for additional significant learning beyond the theoretical one. Such learning, although allowing for investigation of the areas that are taught, requires prolonged stay away from the school, sometimes both during the day and the night and during the different seasons, in order to learn, observe and investigate all the required phenomena.

Often such learning requires advanced technological means (cameras, measuring instruments, sensors, etc.) in open places, for a long time, sometimes without supervision, with all the risks involved. Schools in general are not ready for such learning, therefore thought is required on the subject how to conduct a different learning in this area by bringing nature into the school and making it available for the teachers and the students.

The solution that we have chosen to develop is establishing a controlled microcosm where the teachers and the students can experience and observe together in a controlled reality the processes, which occur in nature. The learners and their teachers, after understanding the studied material, can monitor, process and analyze the data and the indices collected in single environment where different phenomena occurs simultaneously. Analysis of the findings also allows for prediction of the influences and the consequences of the changes, interventions (climate, light and darkness, temperature, insects) on living creatures (fish, frogs, trees, flowers, etc.) and of course examining the results of such interventions later.

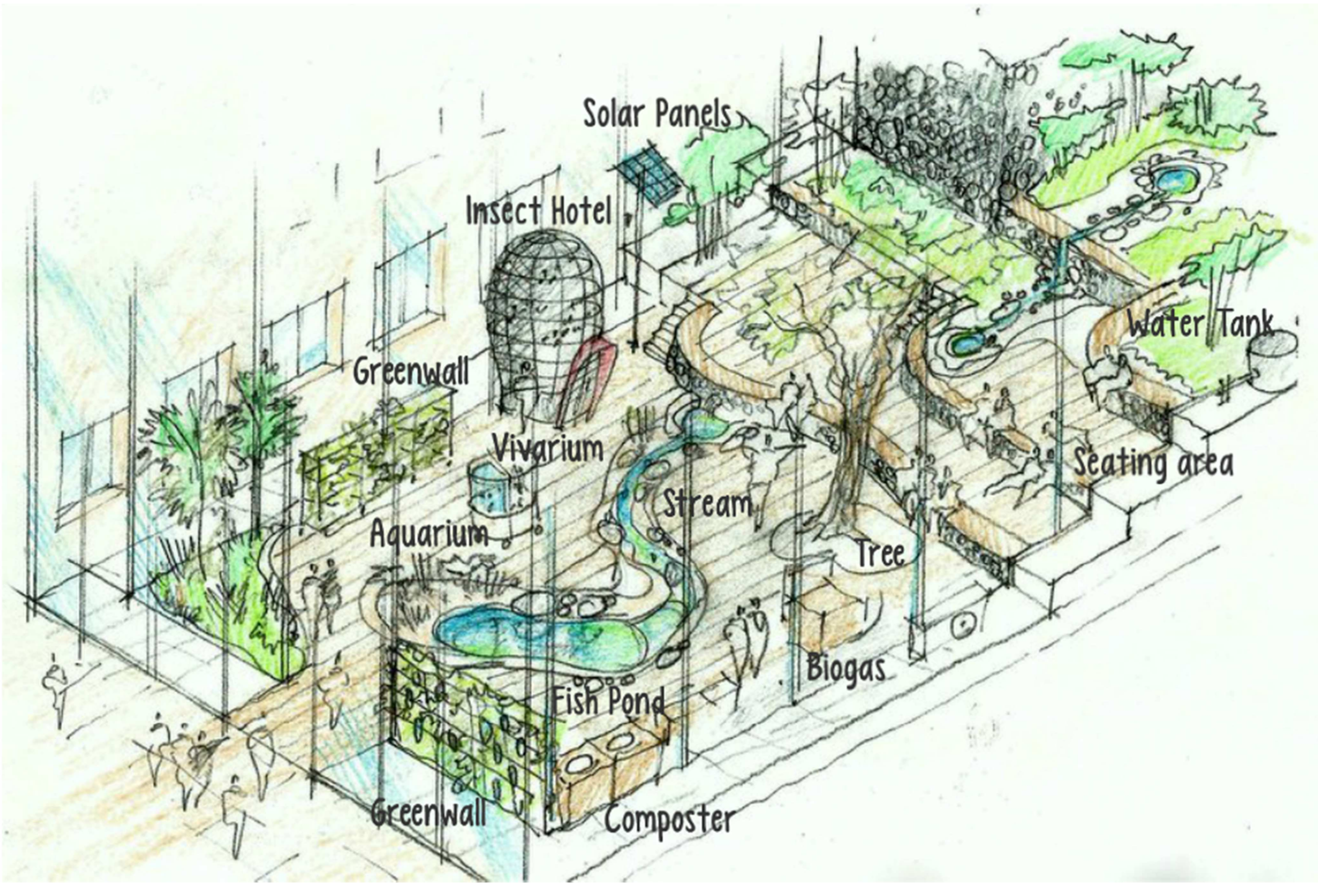

Figure 6. Biophilic learning space.

After understanding in-depth these processes, the symbiosis and the interdependence between them, based on the Big Data collected, the students can later predict changes or suggest solutions to various problems caused as a result of certain disruption or disturbance of the natural processes.

We called the unique space that we had established - the Biophilic Learning Space. In this space, all components of nature have been brought within the grounds of the academic institution. The learning and experimentation space is situated inside a closed, transparent and controlled structure forming an ecosystem encompassing various processes from the animal and vegetable world and eco-environmental activities. The space contains, among the rest, an ecological pond with fish and marine life, amphibians, aquatic plants and three different depth areas, including a swamp and all types of swamp life; a water canal with purified water, which undergoes filtering and purification by microorganisms found in the soil and the roots of plants; an aquarium for observing fish and a vivarium for raising reptiles; a center for raising and observing insects; a nursery that includes all the components, from germination to mature plants, fruit trees etc. The space also serves as an ecological laboratory for teaching processes of energy conservation and recycling: a composter, a biogas system that supplies energy for burning, an instructional solar system for lighting; a natural water cooling system and green walls that demonstrate possibilities for growing hydroponic vegetables and plants on vertical surfaces while using recycled materials.

Figure 7. Biophilic learning space.

The biophilic learning space is monitored by different sensors that display various climatic data in real time, such as temperature, humidity, light, gases, amount of oxygen in the water etc. The space features a climate control unit system based on air-conditioning units for cooling and heating together with a cooling system that operates by adding moisture to the air and two systems for shading and filtering the sun's rays, which are automatically controlled according to the amount of light and heat required at different times of the day and seasons of the year. These computer-controlled systems lead to a reduction in energy costs. The space is equipped with air bellows, which are installed in a chimney on the ceiling and operated by instructions from the control system. The air bellows allow for taking out the hot air when the temperature rises and at the same time the engines can open the walls of the structure so the fresh air from outside can flow in. The space also features an irrigation system and water reservoirs with a total volume of 4500 liters containing recycled water or rainwater (the water is mainly rainwater from drainpipes or condensation water from air conditioners). Water level meters installed in the tank provide information on the amount of water collected. All the systems are connected to a computer, which transmits the data to the screens located in the space. At any time, the students can also check and change the parameters that have been collected by using designated Einstein tablets that also include software for data processing.

3.3.1. Learning in the Biophilic Space

Learning in the biophilic space involves working with advanced technological tools, collecting information, research-based learning, solving problems and planning projects (process-based learning) which allow for learning of the natural processes occurring simultaneously. Within this learning method, the learning group is composed of small teams that investigate and learn together various processes in different work areas. After the students have moved through all the workstations and collected the data from Big Data databases, representatives of the teams meet their counterparts from other groups and report their observations, compare their results and discuss the implications for the processes and phenomena they have observed. In this manner, all the students obtain a holistic picture of the various factors in the space and understand how these factors are affected by the uniform climate conditions during the lesson. When this type of learning takes place over time, the learners can understand how each change affects the plants and the animals living in the space. As part of the learning experience, the learners should develop various tools that improve the processes of learning in the space. To this end, a workshop is available to them containing tools appropriate for production.

3.3.2. Example of Learning Process in the Biophilic Space

The topic of leaves falling off the trees in the autumn is usually taught on a superficial level in elementary school and in greater depth in high school. Like all the other topics, this topic is taught traditionally by reading relevant study materials, frontal teaching during several lessons in the classroom and sometimes experimentation in the laboratory involving measurement of chlorophyll amounts in leaves of different color. Even though the process itself is long (a number of months) and biologically, botanically, chemically and biochemically complex, usually it is covered in several lessons at best.

One of the processes that the students examine in a course on plant physiology conducted in the biophilic learning space is photosynthesis. The activity is intended to improve learners' skills in research-based learning, collecting information and learning anytime and anywhere. In preparation for the lesson, the students independently study the theory behind the process and choose in what area of the space they will do their work. The data, which is being collected constantly by the sensors permanently installed in the space, is available to the students, and they are also equipped with other relevant measuring instruments.

The learning process takes approximately three months, the whole autumn period, while the students follow the falling of the leaves by gathering data and conducting laboratory experiments prepared in advance and compare over the whole process the photosynthetic changes in the leaves of the tree growing in the biophilic space as opposed to the tree growing in uncontrolled environment.

Table 3. Learning Process in the Biophilic Space.

Pedagogical Model Stage	Description
1st round of data collection	Students place the light, temperature and humidity sensors in the right positions surrounding the tree, which is chosen to be measured. Then they place the color sensor next to a leaf. They use their tablet computers to calibrate the system and test the data coming from the sensors. Once everything is in place, they begin the recording of data. Several leaves are being measured in order to get the average value of color and accordingly the number of leaf falls.
Processing and producing results	The light, temperature and humidity data are used to explain the color, which was measured, and the results are presented and explained to the team. Based on the measured data, and on forecasts of the weather station each member of the team predicts the values, which will be shown in the measurements of the following week.
Follow-up	During the week, students are able to view the measurements in real time and follow the values during daytime, nighttime, sunny or rainy days etc. This is also done to identify malfunctioning sensors and to repair them. The teacher is also granted access to the data.
2nd round of data processing, comparing to previous round and producing results	After a week students gather and view the current values of the light, temperature and humidity. They, again, measure the same leaves to get the new average value of color, and compare it with the previous results and with their predictions. Then they analyze the difference between their prediction and the actual results and reach conclusions. This task is performed on a weekly basis.
Correcting the mistakes	During the semester, students that are constantly failing to predict the outcomes of the measurement will be prompted by the system to get back to the knowledge market and study the theoretical information again. They might also be forced to pass a quiz in order to continue their work. Students that are performing well will be prompted to help others and instruct them to get better results.
Outcomes and products of learning	At the end of the semester, the team presents the collected data to the whole group of students. They record their work for the next year and remove the sensors. They publish the results in a readable format, having the data generated automatically by the system. They use photos taken by the camera on the different dates to demonstrate the change. They also suggest further usage of this knowledge (i.e. advising gardeners of the best location to plant a tree).
Evaluation	The evaluation of the learning is done partly by calculating the usage of the system. Improvement in predictions from week to week illustrates that the objective of the activity, improving the competency of learning from searching and questioning, has been met. The overall amount of entries to the system and observations illustrate the level of the student in learning anytime and anywhere.

3.4. Innovation Center - Creator Space

In the recent decades, arts and crafts and nutrition lessons were taken out from the education system and learning through manual work has been discontinued. Nowadays, we have found that there is a need for creating a platform for the college faculty members, the students, and also for the people involved in education in the region, to develop products and/or processes that can assist the students in the education system to develop personal creative skills and integrate into them the elements suited to the 21st century. Thus, the education system, in addition to its role to train and teach, will be able to promote arts and crafts and manual work and in this manner facilitate meeting the needs and the requirements of the society, economy, economics and the State in the future.

3.4.1. Objectives of the Innovation Center

a. Introducing thinking and creative skills in the areas that have disappeared from the education system during the recent decades.

b. Establishing a tool or inbuilt means to identify the breakthrough ideas in the fields that can contribute to the education system by turning ideas into pedagogical and technological products, as well as accompanying, guiding and integrating them in the education systems.

c. Creating a code of conduct and a cooperative activity (We-Code) required for the 21st century industry and society. This code of conduct will serve as a basis for the development of pedagogies that can be implemented in the education system and in the future educational innovative centers.

3.4.2. Areas of Activity of the Innovation Center

The Innovation Center will act to identify and create breakthrough ideas that are different from those that lead the current classical education system, including, among the rest, the development of innovative teaching and learning methods, advanced technologies, designated learning spaces, disciplinary, multidisciplinary and interdisciplinary advanced teaching materials for schools and other educational frameworks, for adapting the education system to the future needs and for closing the gaps between the various student populations from different socioeconomic status.

The staff of the Innovation Center will support establishing a community of thinkers, copywriters and developers, and will act to process the suitable ideas and proposals into action plans while establishing connections with renowned experts on the relevant subjects. The Center will also act to locate ways and means to implement the tools and methods in the education system and will support the distribution of the suitable products.

3.4.3. Innovation Center Principles of Action

a. Transparency - The unit will serve as a model for additional education systems around the world and will operate in an open source mode.

b. Amplification – The Center will strive to establish additional units in colleges and other institutions that will be in constant touch and will constitute parallel thinking units that develop and implement innovative products for the education system.

c. Distribution – The Center will make available to the public and distribute the products and the unit model at the national level.

d. International – The Center will establish contacts with educational institutions in other countries, and will create partnerships and professional relationships with similar units around the world, and will take part in innovative educational product manufacturers network for mutual fertilization.

e. The Center will continue maintaining a community by supplying a flow of innovative information between the regional, national and international bodies with openness, sharing and transparency, for the children of the world and the future of the humanity.

The Innovative Center will be established in a designated building in the campus, which will open its doors daily for educators in the region and for anyone who knows how to express his ideas - children, teachers, parents, managers and industrialists, in the community and in the relevant platforms. The spreading of the news will be done by sending out calls for proposals and individual search for creators and people with ideas in the environment of the relevant platforms. During the course of certain Center activities, Creator Space will be open for lecturers and students, where they will develop skills of working with advanced technologies, project management and creation of prototypes for educational products.

3.4.4. Structure and Work Areas

The Innovation Center will be built on an area of 400 square meters and include several designated work areas:

a. Design: A computerized area that enables designing, drawing and 3D visualization of products, application and software package programming, development of pedagogical VR products, as well as process planning and project management.

b. Robotics and computational thinking: A space for development, testing and operation of various robots for improvement and upgrading of teaching and learning processes.

c. Electronics: An area for working with electrical and electronic components.

d. Arts and Crafts: A space for working with raw materials such as wood, cloth, metal etc.

e. Culinarian space: A working space for the development of learning methods related to the subject of nutrition.

f. Humanities: A quiet space for developing tools and teaching methods for the Humanities.

g. Heavy tools: a space for working with noisier tools.

h. Gatherings and staff meetings: A social space with a coffee corner, armchairs and tables for a comfortable sitting.

i. The WE table: the central table, the heart of the Innovation Center where the meetings and collaborations take place and in which the code of conduct (the We-Code), which is expected of the Innovation Center users, is implemented.

From each space, video calls can be made to relevant Knowledge and Expertise Centers and also to other Innovation Centers.

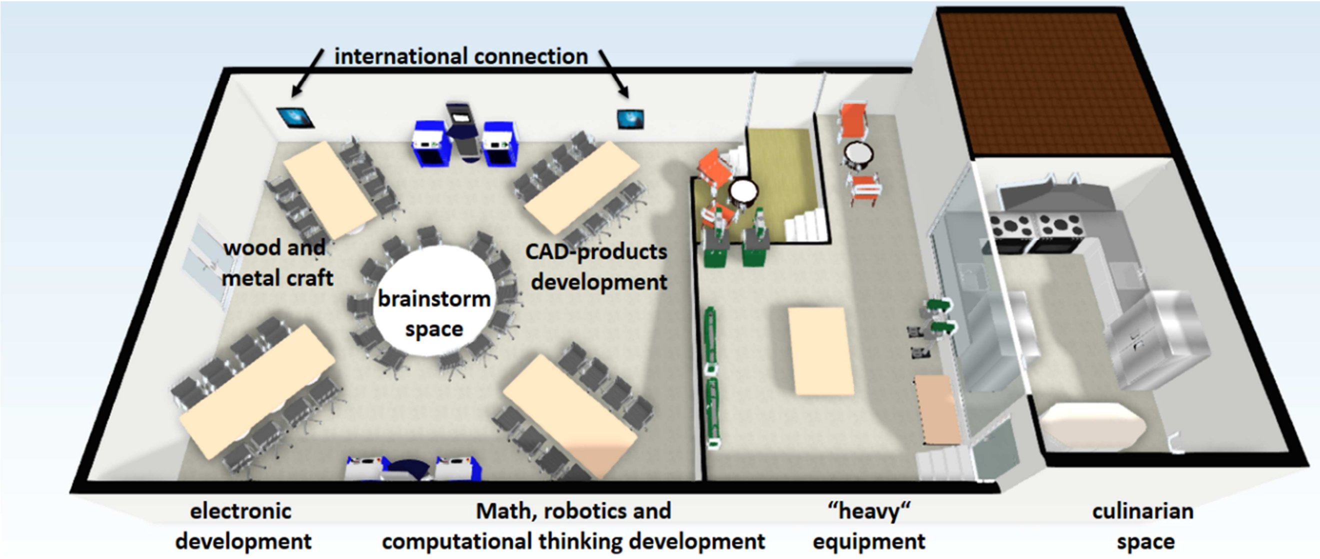

Figure 8. Initial sketch of the Innovation Center and its working spaces – ground floor.

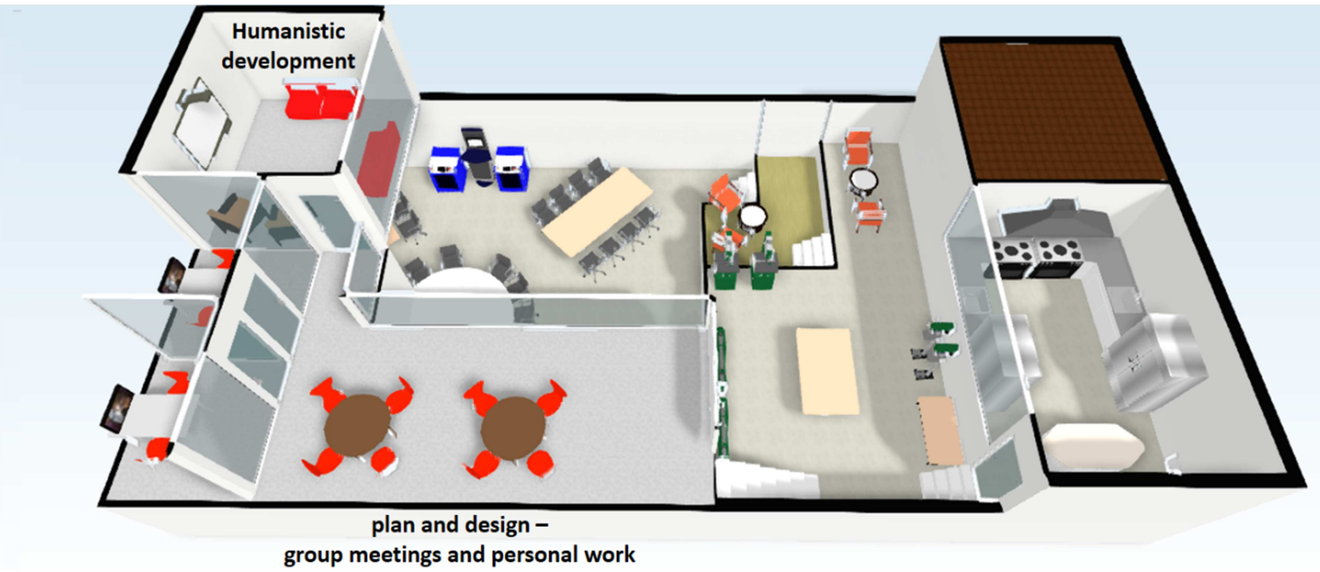

Figure 9. Initial sketch of the Innovation Center and its working spaces – first floor.

4. Conclusion

We believe that not only contemporary and multidisciplinary contents, and not only innovative pedagogies and advanced technologies are integral to the future of schools but also diverse learning spaces adapted to the learners' needs, reflecting the contemporary reality in the 21st century places of employment and workplaces. The future schools will also be based on such thinking, exactly as during the Industrial Revolution the schools were designed according to the workplace concept of community members who sent their children to these schools. Eventually, the education system should stop being influenced only by the outside world. It should start influencing and designing the future workspaces and work processes.

References

[1] Amar, S., & Bar David, N. (2016). Realistic Intelligence and 21st Century Skills in Adapted Learning Environment. American Journal of Educational Research, 4 (8), 588-596.

[2] Stuart, L., & Dahm, E. (1999). 21st century skills for 21st century jobs. Federal Publications, 151.

[3] Trilling, B., & Fadel, C. (2012). 21st century skills: Learning for life in our times. John Wiley & Sons.

[4] Ananiadou, K., & Claro, M. (2009). 21st century skills and competences for new millennium learners in OECD countries.

[5] Collet, C., Hine, D., & du Plessis, K. (2015). Employability skills: perspectives from a knowledge-intensive industry. Education+ Training, 57 (5), 532-559.

[6] Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. Teachers college record, 108 (6), 1017-1054.

[7] Hooper, S., & Rieber, L. P. (1995). Teaching with technology. Teaching: Theory into practice, 2013, 154-170.

[8] Jonassen, D., Mayes, T., & McAleese, R. (1993). A manifesto for a constructivist approach to uses of technology in higher education. In Designing environments for constructive learning (pp. 231-247). Springer, Berlin, Heidelberg.

[9] Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. Theory into practice, 41 (4), 212-218.

[10] Collins, A., & Halverson, R. (2018). Rethinking education in the age of technology: The digital revolution and schooling in America. Teachers College Press.

[11] Ackoff, R. L., & Greenberg, D. (2008). Turning Learning Right Side Up: Putting Education Back on Track (paperback). Pearson Prentice Hall.

[12] Prince, M. (2004). Does active learning work? A review of the research. Journal of engineering education, 93 (3), 223-231.

[13] Freeman, Scott, et al. "Active learning increases student performance in science, engineering, and mathematics." Proceedings of the National Academy of Sciences 111.23 (2014): 8410-8415.

[14] Häkkinen, P., Järvelä, S., Mäkitalo-Siegl, K., Ahonen, A., Näykki, P., & Valtonen, T. (2017). Preparing teacher-students for twenty-first-century learning practices (PREP 21): a framework for enhancing collaborative problem-solving and strategic learning skills. Teachers and Teaching, 23 (1), 25-41.

[15] Coley, R., Cradler, J., & Engel, P. K. (1997). Computers and Classrooms: The Status of Technology in US Schools. Policy Information Report.

[16] Casey, D. M. (2008). The historical development of distance education through technology. TechTrends, 52 (2), 45-51.

[17] Commission of The European Communities (2003). Implementation of the "Education & Training 2010" programme. Retrieved from: http://aei.pitt.edu/42882/1/SEC_(2003)_1250.pdf

[18] Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. Educational technology research and development, 55 (3), 223-252.

[19] Howard, S. K. (2013). Risk-aversion: Understanding teachers' resistance to technology integration. Technology, Pedagogy and Education, 22 (3), 357-372.

[20] Yadav, A., Hong, H., & Stephenson, C. (2016). Computational thinking for all: pedagogical approaches to embedding 21st century problem solving in K-12 classrooms. TechTrends, 60 (6), 565-568.

[21] Mulcahy, D., Cleveland, B., & Aberton, H. (2015). Learning spaces and pedagogic change: envisioned, enacted and experienced. Pedagogy, Culture & Society, 23 (4), 575-595.

[22] Nissim, Y., Weissblueth, E., Scott-Webber, L., & Amar, S. (2016). The Effect of a Stimulating Learning Environment on Pre-Service Teachers' Motivation and 21st Century Skills. Journal of Education and Learning, 5 (3), 29.